Extrusion Transmission and Light Sensitivity

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Outline

- Cliff’s Notes version of NOvA-docDB-378
  - For details, see above
- Extrusion transmission
- Light source sensitivity
- Light filter tests
- Conclusions

Extrusion Transmission Tests

- Tested light sensitivity of PVC, Liquid Scintillator and WLS fiber system
- Method
  - Measure current in photo-detector with a small area (2cm x 4cm) of a PET-Prime 3-cell extrusion exposed to a light source.
  - Subtract background dark current with the area covered.
  - Interpose additional samples of PVC between light source and the extrusion.
  - Ratio of the two measurements is the attenuation of that sample
  - Measure thickness of sample with a micrometer
  - Calculate attenuation length from $\lambda = t/\ln(A)$

Attenuation length results

Sample	thickness(mm)	Dark Current (uA)	Light Current (uA)	Light-Dark in $4cm^2$	Attenuation factor	Attenuation length (mm)
bare	**0**	**0.08**	**1400**	**699.96**		
A1	**1.3462**	**0.08**	**0.16**	**0.08**	**8749.5**	**0.148313**
B1	**1.3716**	**0.08**	**0.28**	**0.2**	**3499.8**	**0.168079**
B2	**1.6002**	**0.08**	**0.12**	**0.04**	**17499**	**0.163789**
B3	**1.3462**	**0.08**	**0.2**	**0.12**	**5833**	**0.155248**
B4	**1.27**	**0.08**	**0.23**	**0.15**	**4666.4**	**0.150329**

- PET-B Attenuation lengths 0.15-0.17mm
  - 15?% TiO_2
- PET-Prime attenuation length 0.19mm
  - 12% TiO_2
- More TiO2 ; More Opaque

Light Source Sensitivity

Lamp	dark	light	light-dark	Relative	Bare APD Current	Area factor	~radiance factor	Signal Radiance factor	Relative
Leon	20	22	2	1.00E+00	1700	32	54400	3.68E-05	1
RED Laser	20.1	20.2	0.1	5.00E-02	3800	1	3800	2.63E-05	0.715789
Blue Led 50mA	20.1	20.5	0.4	2.00E-01	940	1	940	4.26E-04	11.57447

- Module is sensitive to “Leon Light”, a bluish (6400k color temp) fluorescent trouble light, about 2x more than standard (4100k color temp) fluorescent tube.
- Module is most sensitive to blue light, not surprising, due to WLS fiber fluor.
- Module IS sensitive to RED light!!
  - More pronounced sensitivity in our system due to flat QE of APD. (about 20x greater than PMT sensitivity to red light.

Light Filter Tests

Light Source	Bare APD	Yellow filter APD	Red Filter APD	Bare Module	Yellow Filter Module	Red Filter Module
Leon	1400	550	30	1.2	0.25	0.01
laser	3000	2200	220	0.1	0.1	0.01
Blue LED 50ma	940	1.7	0	0.2	0	0

- Yellow filter gives 5X reduction of dark current
- Red filter gives 100x reduction of dark current
- BUT
  - Yellow filter decreases ambient light ~3X
  - Red filter decreases ambient light by ~50X

Conclusions

- The system is most sensitive to blue light that can be shifted by the fiber fluor. For wavelengths absorbed by the fluor they are approximately 20x more problematic than other wavelengths.
- In spite of what Snell's law tells us, the fiber will trap incident light of other wavelengths, but with much lower probability, about 20x. The suspicion is that it does so by scattering the photons, some of which then end up scattered into paths that are trapped. This implies that filtering is not a sufficient solution
- The APD system is about 20x more sensitive to red light than a PMT system due to the flat quantum efficiency.
- The measured attenuation lengths vary from 0.15 to 0.19mm for various samples of PVC.
- For typical lighting intensities approximately 20 attenuation lengths of material are required to reduce the induced dark current to less than 10% of the typical APD dark current, implying a required thickness of 3.0 to 3.8mm.
- For greater margin of safety, insensitive to lamp directly on device we need about 50x more attenuation, or ~24 attenuation lengths, 3.8 to 4.6mm